AUTHOR INDEX

Allen, T. C., 189
Cuculo, J. A., 189
Fan, L. T., 155
Kambour, R. P., 1
Lumley, J. L., 263
Shastry, J. S., 155

SUBJECT INDEX

Abrasion resistance, 171, 210
ABS, 99, 105, 107, 109, 112, 113, 115, 116, 119, 132, 133
Acids, 122
Acrylamide, 172, 175, 217
Acrylic acid, 172, 173, 174, 182, 185, 191
Acrylic esters, 172, 173, 185, 208, 217
Acrylonitrile, 172, 215, 216
Adhesive, 141
Air, liquid, 123
Alcohol, 54, 56, 68, 102, 119, 125; see also Methanol, Ethanol, etc.
Alkali cellulose, 161, 162, 170, 171, 173, 174, 177, 207
Alkanes, 124; see also Pentane, Hexane, etc.
Alkyds, 135
Alloys, metal, 141
Amino acids, 176, 177, 178, 208, 209, 217, 219
Aminoethylcellulose, 173
Anelastic behavior, 93
Anelastic deformation, 2
Annealing, 7, 136
Applications of polymer drag reduction, 264
Arrhenius (kinetics of crazing), 38, 52
Average chain length, 158, 169
  number average, 158, 169
  weight average, 158, 169
  z average, 158

Bases, 122
Birefringence, 40, 41, 44
BPA polycarbonate, 36, 42, 49; see also Polycarbonate
Breakdown of crazes, 43, 46, 57, 59, 60, 71, 81, 84, 91, 93, 96, 98, 117
  effect of solvents on, 121, 132
Brittle failure, 93, 95, 99
Butanol, 5, 61

Capillary phenomena, 14, 15
  capillaries, 54
  capillary action, 41
  capillary pressure, 54
Carboxyethylcellulose 172, 173, 179, 180, 192
Carboxymethylcellulose, 169, 170, 171, 172, 179, 180, 182, 183, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 208, 209, 211, 212, 214, 216, 217, 218, 219
Carboxymethylthiocellulose, 176
Castor oil, 31
Cavitation, in crazes, 58
  in crosslinked glassy polymers, 135
  in crystalline polymers, 139
  in glassy polymers, 22, 31, 34, 41, 42, 47, 58
  in metals, 141
  in rubbers, 140
  requirements for, 142, 144, 145
Cavitational flow, 142
  cavitational deformation, 34
  cavitational stress, 139
Cavity, 32, 58, 59, 65, 122, 142, 143, 144, 145
  and crack initiation, 58, 59, 65
  and craze initiation, 32
  nucleation stress, 142
  surface energy of, reduction by organic liquids, 122
Cellulose, abrasion resistance of, 171, 212
  absorbency of, 168, 171, 187, 189, 190
  accessibility of, 171, 188, 190, 212, 217
  acetate, 181, 194, 215
  aldehyde containing, 160, 171, 211
  amide containing, 171, 172, 175
  amine containing, 166, 173, 175, 176, 189
  anhydride containing, 165, 209
  carbamate, 178
  carbonate, 161, 203, 211
  Carboxyl containing, 160–219
    degree of substitution of, 162, 164, 165, 169, 170, 171, 172, 173, 179, 180, 181, 182, 186, 187, 189, 193, 195, 196, 197, 217
    determination of, 185
    dyeing of, 171, 185, 186, 190, 192, 207
    fiber formation of, 162, 165, 173, 174, 178, 179, 180, 206, 207, 216

hydrogen bonding in, 188, 189, 190, 191
ion exchange of, 171, 181, 182, 183, 184, 191, 216, 217
ionization constant of, 182, 183
mechanical properties of, 161, 163, 165, 166, 171, 178, 180, 188, 189, 192, 193, 198, 212
physical properties of, 168, 171, 178, 187
reactions of, azo formation on, 208, 214, 217
to form acid chlorides, 193, 195, 204, 205
to form novel anhydrides, 165, 209
with acid halides, 210
with alcohols, 194, 195
with aldehydes, 202, 203
with alkyl halides, 199, 200, 201, 207, 210, 214
with amines, 204, 205, 206, 207, 208, 209, 217, 218, 219
with amino acids, 208, 209, 217
with ammonia, 205
with aromatic alcohols, 194
with aromatic diazo compounds, 202
with aziridines, 197, 198, 219
with benzyl halides, 200
with caprolactam, 209, 217
with cellulose hydroxyls, 192, 193
with chloroacetic acid, 199, 200
with chlorocarbonate esters, 209
with compounds containing selenium, 200
with compounds containing sulfur, 200
with compounds containing tellurium, 200
with cyanides, 210
with diazomethane, 201
with diethylchloroacetamide, 200
with dimethyl sulfate, 199
with epoxides, 195, 196, 218, 219
with ethylene diamine, 205
with ethylene glycol, 193
with ethylene oxide, 195, 218, 219
with formaldehyde, 202, 203
with halogenated fatty acids, 199, 200
with hexamethylenediamine, 206, 207
with hydrazine, 207, 208, 217
with hydroxylamine, 207, 208
with methanol, 194
with oxidizing agents, 210, 211, 215, 216
with phenol, 194
with piperazine, 207
with polyamines, 187, 188
with polyhydric alcohols, 194, 195
with beta-propiolactone, 196, 218
with sodium sulfide, 210
with sodium sulfite, 210
with thionyl chloride, 176, 193, 205
with unsaturated alcohols, 194
salt formation of, 164, 166, 168, 179, 181, 182, 184, 185, 186, 187, 188, 190, 191, 192, 208, 216, 217
soiling properties of, 171, 186, 191
solubility of, 162, 178, 179, 180, 181, 183, 192, 193, 195, 197, 198, 199, 200, 202, 205, 206, 208, 209, 211
stability of, 195, 199, 200, 203, 204, 205, 206, 210, 211
thermal degradation of, 190, 191
uses in, antistatic applications, 186
catalysis of cellulose hydroxyl reactions, 211, 212
food applications, 187
medical applications, 186, 187
paper applications, 192, 193, 201
reverse osmosis membranes, 191
soil release, 191
surfactant applications, 186
carboxyvinyl ethers, 175
citrate, 164, 185
cross-linked, 163, 164, 166, 167, 169, 174, 183, 188, 189, 190, 192, 193, 194, 195, 196, 197, 198, 201, 202, 205, 206, 207, 211, 212
crystallinity of, 161, 171, 172, 190, 193, 217

cyanurate, 177
degradation of, 161
degree of polymerization of, 160, 161, 169, 171, 174
degree of substitution on, 162, 164, 165, 169, 170, 171, 172, 173, 179, 180, 181, 182, 186, 187, 189, 193, 195, 196, 197, 217
reactions of, 178, 179, 180, 190, 208, 215, 217
with acetylene dicarboxylic acid, 175
with acid chlorides of polycarboxylic acids, 167, 177, 192
with acrylamide, 172, 175
with acrylonitrile, 172
with aldehydes, 212
with amic acids, 168, 189
with anhydrides of polycarboxylic acids, 166, 167, 192
with carbon disulfide, 162, 174, 207
with carbon sulfoxide, 162, 174
with N-carboxyanhydrides of amino acids, 177, 217, 218, 219
with chloroacetamide, 171
with chloroacetic acid, 169, 170
with crosslinking agents, 211, 212
with dichloroacetic acid, 174, 183
with 2,3-epoxypropionamide, 175
with esters of polycarboxylic acids, 168, 169
with malonic acid, 175
with methyl monochlorocarbonate, 203
with methyl monochlorothiocarbonate, 203
with methyl propiolate, 175
with mixed anhydrides of polycarboxylic acids, 165, 167
with polycarboxylic acids, 163, 164, 165, 173, 175, 192
with beta-propiolactone, 177, 196, 218
with propiolic acid, 175
with salts of polycarboxylic acids, 164, 165
with xanthate esters, 203
Ceramics, 2, 120
Chain cleavage, 122
Chain growth polymerization, 157
Chain scission, 120
Chain segments, 40, 62
Chemical bonds, 85, 87
α-Chlorocarboxyethylcellulose, 174, 185
Chlorodeoxycellulose, 175, 176
Citric acid, 164
Compression, 41; see also Hydrostatic pressure
Concentration necessary for polymer drag reduction, 265
Constant stress layer in drag reducing flow, 281
Continuous variable technique, 168
Copolymerization, 159, 163, 165, 166, 168, 171, 172
binary, 159, 165, 166
composition of, 159, 165, 166, 171
kinetics, 159, 165, 166
multicomponent, 165, 166, 171
reactivity ratios in, 165, 166
sequence distribution of, 166
Cotton, 160, 164, 165, 166, 170, 171, 175, 180, 185, 188, 190, 191, 193, 195, 196, 197, 198, 211, 212, 216
Coulomb-Navier shear failure criterion, 135
Crack growth, 97
Cracking agent, 121, 122, 126
Cracking liquid, 123
Crack initiation, 57, 58, 76, 121
Crack opening displacement, 99, 100, 102
Crack propagation energy, 135
Crack tip crazes; see also Crack tip plastic zone
and Dugdale model, 92
and fatigue cracking of PMMA, 99
and fracture surface layers, 71
and interference fringes, 73, 74, 75, 78, 80
decrease in number of, by fatigue, 81, 98
halo of, in polystyrene, 80
in fatigue cracking of polycarbonate, 101
in fatigue of polystyrene, 96, 97
in polypropylene, 137, 138
number of, and stress intensity factor, 83
recovery of, in PMMA environmental 102, 103
revealed by craze edge grooves, 78

viscoelastic work of extension of, 86
Crack tip plastic zone; see also Crack tip crazes
and Griffith-Irwin theory, 85
in Dugdale model, 91, 92
in Neuber-Cessna-Sternstein model, 88, 89, 91
in polycarbonate fatigue, 101
in PVC fatigue, 100
Craze density. 8, 9, 11, 23
Craze initiation, and fracture, 57
and swelling stresses, 124
at rubber particles, 107, 112
at surfaces, 3
biaxial stress effects and, 28, 29
concentration fluctuations and, 134
crack initiation at low temperature, 65
creep effects on, 43, 51
criteria for, 26, 27
critical stress for, of PMMA in alcohol, 54
in crystalline plastics, 139
in fatigue, 95
kiretics of, 32, 33, 34, 36, 62
molecular weight dependence of, 42, 60
orientation effects on stress for, 40
stress for, 138, 139
stress for, relative to fracture stress, 78, 80
Craze modulus, 20
Craze plane, orientation of, 6, 43, 45
Crazes, low-temperature, 5
Crazes, major features of, 6, 7, 13, 14
Craze stiffness, dispersion in, 94
Craze strain, and craze visibility, 37
and density, 8, 12
and fibrillar stress, 22
and stress-strain curves of rubber-modified plastics, 114
dependence on load, 19, 23
Craze thickness, 7
Crazing agent, 132
Crazing criterion, and orientation direction, 44, 45
applied strain, 26, 30
dilatation and shear, 27, 31
dilatation and strain, 29
hydrostatic pressure, component of, 31
miscellaneous, 31
Crazing liquid, 54, 123, 128
Creep, and growth of crack tip plastic zone, 89, 90
and thermal mode of fatigue failure, 98, 99
effects of crazing and shear flow on, in rubber-modified plastics, 117
effects of, on craze growth kinetics, 50, 51
effects of, on craze initiation kinetics, 32, 34, 36
effects of, on crazing stress, 43
effects of plasticizer on competition of crazing with, 127
molecular weight dependence of, 61
of PMMA and collapse of fracture surface layers, 72
Critical angle, 9, 10
Critical strain, 33, 35, 54, 120, 123, 124, 125, 126
effects of organic liquids on, 120, 123–126
in PMMA in alcohol, 54
in polystyrene, 33, 120
in several glassy polymers, 35
Critical stress, 33, 35, 54, 120
Crosslink density, 136
Crosslinking, 58, 64, 135, 136, 143, 163, 164, 166, 167, 169, 174, 183, 188, 189, 190, 192, 193, 194, 195, 196, 197, 198, 201, 202, 205, 206, 207, 211, 212
Crystallization, 122
Cuprammonium hydroxide, 209
Cupriethylenediamine, 164
Cyanoethylcellulose, 172
Cyclic deformation, 94
Cyclic flow, 94
Cyclic loading, 92
Cyclic stress, 23, 96, 114, 115
Cyclopentanetetracarboxylic acid, 164, 186, 189

Deformation, and craze growth termination, 7
by crazing, in HIPS, 106, 114
categories of, in thermoplastics, 2

crazing and shear, in fatigue, 100
crazing and shear, in rubber-modified plastics, 116, 117
cyclic, 93; see also Cyclic stress
kinetics of, 34
plastic, in crazing, 8
Degradation of polymer solutions in turbulent flow, 270, 280
Density, and craze refractive index, 9
and strain in craze, 8
and stress in craze, 21
in crazes in poly(ethylene terephthalate), 139
number, of crazes, 6, 114
of cavity nucleation sites, 144
packing and order in amorphous plastics, 145
reduction and crazing in HIPS, 106
Dialdehyde cellulose, 160
Diameter effect in polymer drag reduction, 270
Dibutyl phthalate, 36, 37, 51, 52
Dichlorobenzene, 125, 126, 127, 134
Diethylaminoethylcellulose 166, 189
Diffusion, 122
Dilation, 27, 29, 30, 31, 40, 116
and crazing in rubber-modified resins, 116
elastic, effect of orientation on, 40
stress in craze formation criteria, 27, 29, 31
Dispersion index, 164
Domains, in glassy polymers, 12, 145
Drag reduction (defined), 264
Dry Ice, 67
Dugdale plastic zone model, 54, 81, 82, 88, 91, 99, 100
Dynamic Optimization, 176, 177
catalyst feed policy, 177
control of feed temperature, 176, 177
maximum principle, 177
of polymerization reactors, 177
on-line control, 177
start-up control, 177
steady state control, 177
time optimal control, 177
two-position control, 177
"Early turbulence" in drag reducing flow, 272
"Effective slip" in drag reducing flow, 267,
Elastic energy of deformed crazes, 23, 115
Electron microscopy, 4, 14, 19, 20, 22, 106, 138, 146
Electron paramagnetic resonance, 87
Emulsion polymerization, 1.3, 175
effect of agitation, 173
effect of mixing, 173
kinetics of, 173
mechanism of, 173
of copolymerization, 174
of styrene, 173
of vinyl acetate, 173
optimum conditions for, 175
rate of, 173
Environmental, crazing and cracking as practical problems, 119
crazing and molecular weight, 60
crazing in low temperature fatigue, 103
fatigue, 102
stress cracking problems in plastics, 119, 120
Epoxy resins, 31, 99, 135
Ethanol, 5, 52, 53, 119; see also Alcohol
Ethylene glycol dimethacrylate, 135
Eyring theory of flow, 36, 37, 38, 40, 63

Failure; see also Dugdale plastic zone model, Griffith-Irwin theory, Neuber-Cessna-Sternstein model
brittle, and fracture surface craze layer, 71
catastrophic, from cavity in craze, 58, 59
dependence on molecular weight, 61
in fatigue, 92, 93, 96
kinetics, 62
kinetics of, for ABS and HIPS in organic media, 132, 133
low temperature, mode of, 66
mechanism in adhesives, 141
transformation in mode of, by organic agents, 126, 127
Fatigue, and viscoelasticity of craze deformation, 94, 95
crack propagation kinetics, 99, 100

crack tips, shear and crazing at, 100, 101, 102
environmental, of PMMA, 102
failure in polystyrene, mechanisms of, 96
failure, thermal and brittle modes of, 93, 99, 101
life vs frequency in polystyrene, 98
striations, 96, 100, 101
Fibers, transverse bands in, 140
Fibrillation, 136
Fibrils (see also Filaments)
appearance of, 15
deformation of, 90
dimensions of, 15, 140
remains of, on fracture surfaces, 72
rupture and retraction of, 16, 18
rupture kinetics of vs. molecular weight, 60, 61, 62, 76
stress on, vs. void content, 22
Filaments, 48, 49, 72, 142, 143
deterioration of, and crack initiation, 48
in mature craze, 15
remains of, on fracture surfaces, 72
sizes of, from x-ray scattering, 19
skewing of, by shear band, 46, 47
stability of, and craze growth kinetics, 49
strain hardening of, and craze modulus, 20
Flame resistance, 197, 198
Flaw, and low temperature crack initiation, 65, 66, 69
inherent, 57
pigment particle as, in PVC fatigue, 101
submicroscopic, as source of craze void, 144
under triaxial stress, preferential swelling at, 133
Flow stress, 27; see also Shear stress, Yield stress
Fluid mixing, 163, 164, 165, 169, 170, 171, 172, 174
complete segregation, 169, 170, 171
effect of, 169, 170, 171
macromixing, 169, 170, 171
maximum mixedness, 169, 170, 171
micromixing, 163, 165, 169, 170, 171, 174
residence time distribution, 169, 170, 171
Fluids, organic, 41, 60; see also specific chemicals
Fluids, pressurizing, 41
Foam, viscoelasticity of, under cyclic stress, 94, 103
Formamide, 123
Fracture, and orientation direction, 40
brittle, through crazes in polycarbonate, 69
classes of theories of, 84, 85
craze length vs. strain rate at time of, 81
Dugdale model for, 91, 92
effect of modulus change on point of, 82
effect of rubber incorporation on strain at, 105
effects of crazing agents on, 132
effects of orientation on mechanism of, 83
energy and craze layer thickness vs. molecular weight, 66
energy and inherent flaw size, 63, 64, 65
energy sinks in, 85, 86, 87
extent of craze prior to, 67, 68
fatigue, and craze cyclic deformation, 93, 94
fatigue, in liquid nitrogen, 103
initiation in small craze, 70
jumping of, between crazes in polystyrene, 80
local stress theories of, 88
mechanisms of, in PMMA and polystyrene, 71, 72, 73, 74, 75, 76
Neuber-Cessna-Sternstein model for, 88, 89, 90
of metals, cavitation during, 141
of polystyrene under hydrostatic pressure, 31
of polystyrene vs. molecular weight, 60
of pre-cracked specimens, 57
review of crazing and, 2
velocity of, and secondary craze production, 77, 80
Fracture energy, 63, 69, 81, 82; see also Fracture surface energy
and fracture surface smoothness, 81
and inherent flaw size, 63
and secondary crazing, 82
of crazes, 69

Fracture surface energy, 63, 64, 80, 84, 85, 104, 131, 135
  influence of pre-crack craze size on apparent, 63, 64
  in Griffith theory, 84
  related to Irwin's strain energy release rate, 85
  velocity dependence of, 80
Fracture surface layer, composition, thickness and relation to fracture energy, 70, 71, 72
  energy requirements for production of, 86, 87
Fracture toughness, 100, 135
  and craze strength, 81
  and rubber modification, 104
  in crosslinked resins, 135
  related to fatigue crack resistance, 99, 100
Free radical polymerization, 173, 213, 214 215, 216, 217
Frequency, 94, 95, 97, 98, 99, 102
  and crack tip sharpening, 98
  and environment fatigue crack growth rate, 102
  and fatigue crack growth rate, 102
  and fatigue life, 97, 98
  and modes of fatigue failure, 99, 101
  of cyclic stress and craze stiffness, 94, 95
Fumaric acid, 53, 175

Gel permeation chromatography, 164
Generating functions, 168
Gin, 120
Glasses, 2, 120
Griffith equation, 69
Griffith-Irwin theory, 63, 84, 85

Hashin's equations, 110
Helical structure, effect on drag reduction, 265
Helium, 67
Hexadecane, 129
Hexane, 129
High impact polystyrene, 105, 107, 119; see also Rubber-modified polystyrene and HIPS
  electron micrograph of crazed, 107
  optimum rubber particle size in, 119
  yielding and stress whitening of, 105
Hill shear yield criterion, 139
HIPS, 105, 106, 107, 108, 109, 112, 114, 115, 132, 133; see also High impact polystyrene and rubber-modified polystyrene
  crazing contribution to creep in, 117
  cyclic stress-strain behavior of, 114, 115
  effect of pressure on toughness of, 116
  environmental stress cracking kinetics for, 132
  impact strength vs. rubber particle size in, 112
  mixtures with poly(phenylene oxide), 118, 119
  yielding and stress whitening in, 105, 106, 107, 108, 109
Hot film unit, effect of polymer solutions on, 278
Hydrocarbons, aliphatic, 129; see also specific compounds
Hydrogen bonding, 122, 128
Hydrostatic compression, 29
Hydrostatic pressure, 31, 39, 41, 42, 115
Hydrostatic tension, and cavitation in rubbers, 140
  and extent of crazing in rubber-modified polymers, 119
  and failure in adhesives, 141
  component of crazing criteria, 27, 29, 31
  component of shear yield criteria, 28
  effect on swelling equilibrium, 133, 134
  inherent flaws and cavitation, 144

Impact energy in rubber-modified plastics, 104, 105
Impact strength, 104
  dependence on rubber particle characteristics, 111, 112
Impact toughness and rubber modification, 104, 109
Impact tube measurements, effect of polymer solutions on, 278
Inherent flaw, 57, 59, 63, 64, 144
Initiation system, 156, 157
  free radical, 157
  ionic, 157

Intercrystalline links, 136
Interference colors, 70, 71, 72, 81, 96
Interference fringes, 72, 73, 74, 75, 76, 77, 79, 87
  from craze at crack tip, 73, 74, 75
  from radial cracks, 76, 77
Internal stress, 121
Intrinsic drag reduction, 266, 283
Intrinsic flaw; see also Inherent flaw
  pigment particle as, in fatigue cracking of PVC, 101
Intrinsic viscosity, change in pure strain, 277
Iodine-sulfur mixtures, 106, 108, 137
Itaconic acid, 53, 175

Kelvin equation, 14
Kerosene, 31

Laplace equation, 14
Large eddies in turbulent shear flows, 284, 286
Length scales in drag reducing flow, 272
Liapunov's method, 179
Liquids, organic, early studies of effects of, on crazing, 120
  in tests of residual molding stress, 121
  replacement in craze by aqueous solutions, 14
  roles in mechanisms of crazing and cracking, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134
  use as pressurizing fluids, 41
  widespread effects of, on craze initiation, 43, 119
Liquids, wetting, 123, 126; see also Capillary phenomena, etc.
Lorentz-Lorenz equation, 10, 74

Maleic acid, 174, 183
Maleic anhydride-diethylene glycol polyester, 135
Maximum drag reduction asymptote 267, 283
Metals, 141
Methacrylate-butadiene-styrene, 106, 112
Methacrylic acid, 173, 174, 181, 182, 185, 191
Methacrylic esters, 173, 182
Methanol, craze initiation kinetics of polystyrene in, 33, 120
  growth kinetics of PMMA crazes in, 53, 130, 131, 132
  transformation of polycarbonate craze to neck in, 48
Methylene chloride, 84
Methyl methacrylate, 135
Microfibrils, 15
Micromixing, 163, 165, 169, 170, 171, 174
Microstructure, of crazes, 12, 15, 20
  of glassy polymers, 145, 146
Mineral oil, 59
Modeling, 156, 161, 162, 172, 174
Mohr-Coulomb yield criterion, 28
Moisture absorbency, 168, 171, 187, 189, 190
Molecular extension, in steady flow, 274
  in turbulent flow, 280, 283
Molecular interaction, 266
Molecular weight distribution, 156, 158, 163, 164
  moments of, 158, 168
  of polymers, 156, 164, 167, 176
Molecular weight, effect of, on crack tip deformation zone shape, 90
  on craze initiation, 32, 42
  on craze stability at crack tip, 75, 76
  on craze strength, 60, 61, 63
  on critical craze size, 59
  on fracture surface layer thickness, 72
  on inherent flaw size, 64, 65
  on number and size of crazes at fracture, 60
  on radial crack number density, 76
  on secondary crazes, 77, 78, 79, 80
  on ultimate properties, 42
Monomer, 159, 160, 161, 162, 163, 164, 165, 166, 167, 169, 170, 171, 172, 173, 174, 175
  conversion of, 161, 162, 163, 167, 169, 171, 173, 174
Morphology, and craze growth, 43
  of craze, 4, 21
  of fracture, 70, 106
Multiphase polymerization, 172, 173, 174

Neuber-Cessna-Sternstein model, 88, 89, 90, 91
"Newtonian plug," 267
Newton's rings, 76, 77
Nitrogen, as stress crazing agent, 39, 66, 67
  craze size in, 68
  crazing of silcone rubber in, 140
  effect of, on low temperature crazing limit, 71
  fracture surface energy in, 69
  role of, in crazing mechanism, 123
Non-Newtonian behavior of drag reducing solutions, 265
Nylon, 140

Octahedral shear stress, 28
Oldroyd equation, 274
Onset of drag reduction, 265, 272
Optimal reactor design, 174, 175
  manipulating variable, 175
  optimal monomer feed policy, 174
Optimal systems synthesis, 179, 180
Organic agents, 121, 126
Organic liquids; see Liquids, organic
Organic vapors, 126
Orientation, and fracture surface energy, 83
  and inherent flaw size, 64
  effect of, on craze initiation resistance, 39, 40, 41
  effect of, on crazing and shear in rubber-modified plastics, 117
  effect of, on failure kinetics, 63
  effect of, on fatigue life on polystyrene, 98
  effect of residual, on crazing criterion, 31, 32
  in crazes from x-ray halo, 4
  in fracture surface layer, 70
  in shear band and craze deflection, 46, 47
  molecular, and craze plane direction, 6, 43, 44, 45
  molecular effect on craze x-ray scattering, 19
  test for residual molding stress and, 121
Osmium tetroxide stain, 106
Oxygen, as stress crazing agent, 39, 66
  effect of, on low temperature crazing, 71
  fracture surface energy in, 69
  role of, in crazing mechanism, 123

Peclet number, 170
Perfluorocarbons, 123
PET, 139; see also Poly(ethylene terephthalate)
Phenolics, 135
Phthalic acid, 163, 181, 183, 185, 191
Pituity of drag reducing solutions, 279
Plane strain, 24, 100
Plane stress, 56, 136
Plastic deformation, 106
  and craze polymer density, 8, 12
  of rubber-modified polystyrene, 106, 114, 115
  temperature of, and resulting birefringence, 41
Plastic flow, and fatigue cracking resistance, 100
  and strain hardening in polystyrene, 16
  effect of temperature and swelling on, 53
Plasticity, 2, 20
Plasticization; see also Swelling
  effect of, on T_g and $\Delta F_{g,l}$, 130
  role of organic liquids and vapors, 123, 124, 125, 126, 127
Plasticizer, craze growth kinetics for PMMA and, 49, 52, 53
  effect of, on T_g and crazing resistance, 124, 125, 126
  fracture kinetics of PMMA containing, 37, 132
Plastic strain, 40
Plastic work, of craze formation in HIPS deformation, 115
  of crazing in crack propagation, 85, 86
Plexiglas, 34, 80, 87, 92; see also PMMA and Poly(methyl methacrylate)
PMMA, 27, 28, 31, 34, 36, 37, 39, 43, 44, 45, 49, 50, 51, 52, 53, 55, 56, 57, 59, 60, 62, 64, 65, 66, 68, 69, 70, 71, 72, 73, 74, 75, 76, 78, 79, 80, 81, 82, 83, 86, 90, 92, 93, 98, 99, 102, 104, 114, 115, 116, 119, 120, 123, 127, 130, 131, 132, 135, 139; see also Plexiglas and Poly(methyl methacrylate)
Poisson's ratio, 29, 40, 116,

Polyamides, 122
Polybutadiene, 109, 110, 111
Polycarbonate, 3, 5, 13, 14, 19, 20, 23, 27, 31, 32, 35, 38, 44, 48, 49, 50, 56, 59, 68, 69, 71, 86, 93, 94, 99, 100, 101, 102, 103, 104, 114, 122, 123, 127, 139, 146
Poly(dimethyl phenylene oxide), 42; see also Poly(2,6-dimethyl-1,4-phenylene oxide)
Poly(2,6-dimethyl-1,4-phenylene oxide), 15, 16, 18, 35, 107, 123, 128
Poly(diphenyl phenylene oxide), 42, 43; see also Poly(2,6-diphenyl-1,4-phenylene oxide)
Poly(2,6-diphenyl-1,4-phenylene oxide), 15, 26, 46, 47
Polydispersity, 164
  effect of in drag reducing solutions 272, 284
Polyesters, 122, 135
Polyethylene, 99, 136, 140
Poly(ethylene terephthalate), 39, 123, 138, 140; see also PET
Polymer, molecular weight distribution of, 156, 158, 163, 164
  molecular weight of, 156, 162, 163, 164
  structure of, 156
  weight fraction of 161, 168
Polymerization, branching in, 164
  chain growth, 157, 158
  chemistry of, 156
  copolymerization; see copolymerization
  degree of, 163, 165, 170, 171, 173, 175
  depolymerization, 160
  free radical, 161, 162, 163, 164, 166, 167, 168, 171, 172
  heat of, 156, 160, 161
  radiation induced; see Radiation induced polymerization
  step, 157
  systems engineering, 156
  thermodynamics of, 160
Polymerization reactors, 156, 161, 162, 163, 164, 165, 168, 169, 170
  analysis of, 156, 161
  control of, 156, 161, 164, 165
  design of, 156, 163, 174, 175, 176
  dynamic analysis and stability of, 156
  modeling of, 156, 161, 164, 165
  mixing in; see fluid mixing
  operation of, 162, 168
  optimization of, 156, 174, 175, 176
  periodic operation of, 168
  plug flow, 168, 170, 172, 176
  systems synthesis of, 179, 180
Poly(methyl chloroacrylate), 43
Poly(methyl methacrylate), 25, 27, 34, 35, 43; see also Plexiglas and PMMA
Poly(phenylene oxide), 36, 51, 68, 118, 123, 124, 126, 127; see also Poly(dimethyl phenylene oxide) and Poly(2,6-dimethyl-1,4-phenylene oxide)
Polypropylene, 137, 138, 140
Polystyrene, 6, 17, 19, 20, 22, 25, 27, 29, 30, 31, 33, 34, 35, 36, 37, 38, 39, 40, 42, 43, 48, 51, 57, 58, 59, 60, 61, 64, 65, 68, 69, 71, 72, 73, 75, 76, 77, 80, 81, 83, 87, 91, 94, 95, 97, 98, 99, 103, 104, 105, 106, 108, 109, 110, 111, 114, 115, 118, 119, 125, 127, 129, 133, 145, 147; see also High impact polystyrene, Rubber-modified polystyrene, and HIPS
Polysulfone, 35, 42, 125, 126, 128, 130
Poly(vinyl chloride), 100, 101, 129
Pressurizing fluids, 41
Propylene glycol, 121
PVC, 100, 112; see also Poly(vinyl chloride)

Q-e scheme, 166

Radiation induced polymerization, 167
  γ ray initiated, 167
  of ethylene, 167
  of styrene at low temperatures, 167
  optimum design of, 157
Reactors, batch, 161, 162, 163, 164, 165, 166, 167, 168, 170, 171, 172, 173, 174
  continuous, 161, 164, 165, 167, 168, 170, 171, 174
  homogeneity of, 156
  residence time, 156, 169, 170, 171, 174

stirred tank, 161, 162, 163, 164, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175
Recycle, 163, 165, 168
Reflectivity, disappearance of, in crazes near T_g, 7
effect of large voids on, 19
effect of lateral collapse on, 48
of crazes, 3, 6
of liquid-filled craze, 10
Refractive index, and craze density, 10, 11, 139
and craze optical thickness, 51, 52
and thickness of surface layer, 71, 72
and visibility of craze, 7
change of, with emptying of craze, 14
interference fringes and crack tip profile, 73, 74
measurement of craze, 9, 10
of crazes in rubber-modified polystyrene, 106
of fracture surface layer, 70, 71
Resol-formaldehyde resin, 136
Rubber, 19, 30, 46, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 115, 116, 117, 119, 126, 135, 136, 140, 141, 142
Rubber modification, 106
Rubber-modified acrylic polymers, 104
Rubber-modified polystyrene, 106, 126
Rubber particle, 104, 105, 106, 107, 109, 110, 111, 112, 117, 119, 135, 136
Rubber toughening, 105, 112, 113, 116, 135

Saturation effect in drag reduction, 266, 283
Shear bands, 140
in deformed HIPS/polyphenylene oxide mixtures, 107, 118, 119
interaction of crazes with, 25, 27, 46
termination of crazes by, in fatigue, 101
Shear craze, 138, 139, 140
Shear criterion, 31, 139
Shear deformation, and craze growth termination, 7
and fatigue crack growth resistance, 100, 101
in creep of rubber-modified plastics, 117
Shear failure, Coulomb-Navier criterion for, 135
Mohr-Coulomb criterion for, 28
Shear flow, 101
Shear stress, see also, Flow stress
at craze tip, 25
in crazing and shear yield criteria, 27, 28, 29, 31
Shear yielding, and ability to craze in crosslinked resins, 136
and shear crazing in PET, 139
in cold drawing of ABS, 105
interaction of crazing with, in rubber-modified resins, 116, 117
restraint of, as requirement for crazing, 142
stress criterion for, 28, 135
Silicone, 54, 140
Snell's law, 10
Solubility, 120, 121, 123, 127, 128, 129, 130; see also Plasticizer and Plasticization and Liquids, organic
Solubility parameter, 127, 128, 129, 130, 131
Solution polymerization, 163, 172
Solvent crazing, as subclass of environmental failure, 120
as test for residual molding stress, 121
correlation of solubility parameter with resistance to, 127, 128, 129, 130
from pre-inserted cracks, 53, 54, 55, 56, 131, 132
mechanisms of, 121, 122, 123, 124, 125, 126
prominence of, 43
theories of, 133, 134
Sorption; see also Swelling
of water in PMMA, 120
Specific refraction, 11, 74
Spherulites, 136
Stability analysis, 157, 177, 178, 179
of addition polymerization, 178
of chemical reactors, 177, 178, 179
of multiphase reactors, 179
of tanks-in-series model, 179
perturbation technique, 179
Starch, 79, 201

Step (condensation) polymerization, 157
statistical approach, 168
Strain; see also Deformation
and craze initiation time, 32, 33, 34, 35, 36, 37
and stress at crack tip, 88, 89, 90, 91, 92
at fatigue crack tip and Dugdale model, 100
birefringence and craze initiation stress, 40
dependence of craze deformation characteristics on, 22, 23, 24, 94
effect of orientation on, for craze initiation, 39
effect of pressure on HIPS fracture, 115
elastic and plastic components of, in craze at fracture, 85, 86
for crazing and fracture vs molecular weight, 60
in craze vs orientation direction, 44
in shear band and craze diversion, 46
in stressed crazes in HIPS, 114
lateral vs longitudinal strain in creep of rubber-modified plastics, 116, 117, 118
threshold for craze initiation, 26, 27, 29
threshold of, for polystyrene in organic liquids, 120
Strain amplitude, in craze vs bulk during fatigue, 93
Strain energy release rate, 63, 85
Strain hardening, and constancy of craze thickness, 7
and craze filament stability, 143
and fracture energy, 85
lack of, in polystyrene, 16
of filaments vs. craze stiffness, 15
pre-orientation and fracture energy, 83
Strain rate vs. craze size at fracture, 59
Stress; see also Tension, Tensile stress
amplitude of, and fatigue crack growth, 96
and craze growth rate, 50
and rupture time of solids, 62
axiality of, and craze tip profile, 56
concentration of, at rubber particle equator, 107, 108, 110
critical level of, for craze or crack growth, 35, 131
dilatation, in crazing criterion, 27, 29, 30, 31
effect of orientation on craze initiation, 39, 40
endurance limit in polystyrene fatigue, 97
in and around craze, 21, 22, 23, 24, 25
magnitude of, and craze initiation time, 32, 33, 34, 35, 36, 37
major principal, and craze plane orientation, 43, 44
perturbation of, by craze, 46
residual molding, test for, 121
theories of fracture, 88, 89, 90, 91, 92
Stress amplitude, 93, 96
Stress intensity factor K, and solvent craze growth kinetics, 53, 54, 55
change of, vs. fatigue crack growth, 99, 100, 101, 102, 103
for polystyrene crack propagation, 83
Stress relaxation, 33, 126
Stress whitening, at polypropylene crack tip, 137
crazing as source of, in rubber-modified plastics, 105, 106
effect of, on mechanical properties of rubber-modified plastics, 114, 115
in rigid PVC, 100
in rubber-modified epoxies, 135
in swollen homopolymer, 126
temperature dependence of, in impact of ABS, 113
Striations, on polycarbonate fatigue fracture surfaces, 101
on polystyrene fatigue fracture surfaces, 96, 97
on PVC fatigue fracture surfaces, 100
Structural turbulence in drag reduction, 272
Structure, of glassy polymers, 144, 146
Structure of crazes, 15, 16, 44, 60, 138
Styrene, 109, 135
Styrene-acrylonitrile copolymer, 35, 42
Sublayer stability in drag reducing flows, 270
experimental, 272

three dimensional, 271
Succinic acid, 163, 182, 183, 189
Sulfoethylcellulose, 182, 183
Sulfur, 15, 16, 17, 18
Surface cracking, 120
Surface energy, 85, 87, 122, 123
Surface groove, 4, 5, 6, 8
Surface scratches, 8, 137
Swelling, 120, 121, 122, 123, 124, 125, 126, 127, 130, 132, 133; see also Solubility and Sorption
Systems, polymer-solvent, for drag reduction, 264
Telomers, 173
Temperature, 160, 167, 168, 169, 175, 177, 179
ceiling, 160
low, craze edge discontinuity at, 5
crazing resistance at, 38, 39
fatigue fracture of PMMA at, 103, 104
favoring of crazing process at, 39, 44
fracture surface energy at, 69
Izod impact strength of ABS at, 113
mode of crack initiation at, 65, 66
nitrogen, oxygen, and CO_2 as crazing agents at, 66, 67, 123
relaxations at, and crazing resistance, 43
roughness of fracture surface at, 71
Tensile strength, 161, 164, 165, 166, 167, 171, 176, 178, 180, 192
Tensile stress; see also Critical stress and Critical strain
and cavitation in domains in glassy polymers, 13
as requirement for crazing, 3, 27, 28, 29
critical level of, for craze initiation, 33, 34, 35
in and around craze, 21, 22, 23, 24, 25
orientation dependence of, 40, 41
pressure dependence of, 41, 42
temperature dependence of, 36, 37
vs. craze initiation time, 32, 33, 34, 35, 36
Tension, acceleration of absorption by, 56
hydrostatic, in stressed adhesive bonds, 141
Thermodynamics, of polymerization, 157, 160, 161
Thermoplastic elastomers, 140
Thin films, crazing in cores of, from swelling stresses, 121
microstructure of amorphous, 146
on fracture surfaces, 70, 71, 72, 74, 136
Time scales in drag reducing flow, 284, 272
Toughening; see Rubber toughening
Toughness, and craze at crack tips, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 85, 86, 87, 88, 89, 90, 91, 92
and fatigue crack resistance, 99, 100
and rubber modification, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119
effect of craze compliance on, 19, 20, 23
multiple crazes at crack tips and, 24
viscous and plastic motions and crack-, 57
Tower polymerizer, 170
Towing tanks, drag reduction in, 264
Turbulence in polymer solutions, 284, 287

Vegetable oil, 132
Viscoelastic behavior, and thermal mode of fatigue, 93
of craze and fatigue characteristics, 93, 94, 95, 102, 103 of craze vs. craze strain, 19, 20, 23
Viscoelastic fracture work, 86
Viscose rayon, 162, 168, 169, 174, 179, 185, 206, 207
Viscos solution, 162, 165, 173, 174, 179, 202, 206, 207, 210
Viscosity, 163, 171
Viscous damping of craze, 103
Viscous energy of craze deformation, 115
Viscous liquids, 121
Viscous sublayer in drag reducing flow, 282
Void content, 11, 15, 19, 20, 22, 70, 94, 114; see also Volume strain
and craze fibrillar stress, 22
and interference colors in fracture surface layer, 70
and strain of crazed HIPS, 114, 117
from craze refractive index, 11
of craze and craze modulus, 19, 20

of drawn PET, 139
of shear crazes in PET, 139
uniformity of, to craze boundary, 15
viscous resistance to cyclic change of, 94
Voids, and x-ray scattering from fracture surface, 70
and x-ray scattering from stressed crystalline polymers, 140
in deformed, rubber-modified epoxy, 136
in drawn PET, 139
in fracture of metals, 141
interconnection of, 14
macroscopic, and crack nucleation, 67
nucleation of, at craze tip, 42
number of, for craze visibility, 30
size of, and craze opacity, 19
from capillary vapor pressure, 14
from craze growth kinetics, 54
from electron microscopy, 15, 18
from x-ray scattering, 19
surface energy of, in fracture surface layer, 87
Volume strain, 116, 117, 118

Water, 52, 72, 120
Water absorbency, 168, 171, 187, 189, 190
Wrinkle recovery angle, 166, 188, 189, 192, 193, 198, 212

X-ray halo, arcing of, from crazed polystyrene, 4
X-ray scattering, and craze element sizes, 19
and craze specific internal surface area, 87
and polymer chain end-to-end distance, 147
from crack tips in rubber, 141
from fracture surfaces, 70, 71
from stressed nylon, polypropylene, PVC and poly(vinyl butyral), 140

Yielding, and craze termination, 51
and stress whitening in HIPS, 105
at fatigue crack tip in PVC and polycarbonate, 100, 101
effect of plasticizer on ease of crazing and, 127
flexed bond theories of crazing and, 133
relative amounts of crazing and, in rubber-modified polymers, 118, 119
Yield stress, and crazing of swollen films, 126
and plastic energy of craze formation, 86
and stress whitening of PVC, 100
attainment of, in polystyrene by orientation, 45
differences of, and cavitation in alloys, 141
in biaxial testing of epoxies, 135
in craze, 20
in Dugdale crack tip plastic zone, 91, 92
influence of, on fatigue failure mode, 93
magnitude of, and ease of crazing, 142
of HIPS, 114, 115
temperature dependence of crazing stress vs., 37, 38, 39
vs. craze strength, 7

Z transform technique, 168, 169